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A Management Decision Framework for Winnowing Simulated All-Aged Stand Prescriptions

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RESEARCH SUMMARY

Forest managers have a vast spectrum of stand prescriptions and regimes from which to choose. Evaluation to find the optimum prescription for a specific stand, or class of stands, could take days or weeks. The methodology for evaluating uneven-aged and all-aged stands has been especially limited. Forest managers need a quick and effective procedure for finding the optimum all-aged prescription for a specific stand.

The forest owner's management objective provides the scale for judging an optimum prescription. The objective is usually to maximize some measure of biologic or economic productivity. Productivity measurement units are frequently: (1) periodic annual increment (PAI) in cubic foot volume (PAICV); (2) PAI in merchantable volume (PAIMV); (3) present net worth of future incomes (PNW); and (4) land (soil) expectation value (LEV). The first three are well known. LEV solutions for all-aged stands have been available only since 1980.

Iterative methods are commonly used to find the one prescription with the greatest estimated productivity. In these methods the productivity of the first prescription is estimated. Then, one prescription element is stepped, up or down, and the next prescription evaluated. When all elements have been varied (stepped) within appropriate limits, the prescription with the maximum estimated productivity, and meeting all constraints, is selected.

Stage's Prognosis Model is used for simulating stand growth and estimating productivity per acre in cubic and board foot volumes. The need for a large number of prescription iterations based on the model suggests an executive ADP program to efficiently build and index prognosis stand files and quickly submit the many prognosis jobs. The WINNOW programs were developed to meet this need. As many as 10 prognosis jobs per minute can be submitted through WINNOW.

Stand biological productivity is read from the prognosis job output for each trial cutting cycle. The tree value classes and a simple set of desk calculations provide the LEV. The tabulated biologic and economic productivity results clearly indicate relations between trial prescriptions so managers can select the optimum prescription for the specified objective.

The WINNOW procedures were used in 1980 to evaluate a stand of ponderosa pine for the Idaho Department of Lands. The legislated objective equated with maximum LEV—the revenues support Idaho schools. Uneven-aged management had been prescribed. A total of 18 stand options were evaluated for each of three cutting cycles—54 stand prescriptions. The indicated optimum stand prescription showed potential productivity increases over current annual growth as:

LEV, dollars/acre(/ha) $8 to $36 ($19 to $89)

PAICV, ft^3/acre (m^3/ha) 85 to 112 (5.95 to 7.84)

PAIMV, bd.ft./acre(/ha) 230 to 473 (568 to 1,169)

The stand was immediately marked (1981) to approach the optimum prescription.

THE AUTHORS

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INTRODUCTION

"Winnow:...to remove...to get rid of...to separate desirable and undesirable elements" (**Webster's New Collegiate Dictionary**, 1977).

In our research we apply the term "winnow" to the selection of one, best, all-aged stand prescription from among many possible prescriptions. There could be many prescriptions, for instance, for the stand pictured in figure 1. But which would be the best silvicultural/managerial prescription? (For a definitive answer for this stand, see the case study later in this paper.)

Sound prescriptions will, implicitly or explicitly, recognize and consider the owner's objectives, land productivity, and site protection. Land productivity concerns should include a balance of forage, timber, and water production, of wildlife habitat maintenance, and of human amenities. Site protection recognizes the controlled occurrence and judicious use of fire. Soil productivity is maintained by reducing compaction and erosion and by increasing fertility. Vegetation is maintained to protect the site and is controlled to meet productivity objectives and limit losses caused by insects and disease. Prescriptions must be economically feasible and consider the biological requirements of stands for regeneration, growth, and control of mortality agents. But even with these considerations, the owner's objectives generally provide the test for a "best" prescription and the units for measuring the approach to "best."

An all-aged stand prescription has at least five elements (Alexander and Edminster 1978; Gibbs 1978): four prescribe the reserve stand at the start of the growth period, and the fifth defines the cutting cycle. The elements are:

1. Species composition – percent by volume or basal area of each species.
2. Stand structure – the distribution of trees by age-size (diameter) classes.
3. Maximum tree size (diameter) – the largest tree retained in the size distribution.
4. Stand density – a quantitative measure of tree stocking in absolute terms, generally total basal area per unit area.
5. Cutting cycle or interharvest period (Hall[1]) – the time between successive cuts in a stand (after Ford-Robertson 1971).

Using these elements, an abbreviated code identifies each prescription. For example:

PP60DF40–1.20–16–60–12 (English), or
PP60DF40–1.20–40.6–13.8–12 (metric)

identifies a stand with these characteristics:

Species composition, percent basal area: ponderosa pine 60, Douglas-fir 40
"q" structure, 2-inch (5-cm) classes: 1.20
Maximum reserve diameter at breast height (d.b.h.), inches (cm): 16 (40.6)
Reserve stocking, basal area, ft^2/acre (m^2/ha): 60 (13.8)
Cutting cycle, year: 12

Despite such lists of objectives and elements, an answer as to which is the best all-aged prescription for a particular stand has not generally been available. We would like here to discuss the question and to give an objective procedure for selecting all-aged prescriptions. We assume a rational decisionmaker with a social conscience and resource concerns that extend over many generations.

Figure 1.—What is the best silvicultural/managerial prescription for this stand of ponderosa pine near New Centerville, Idaho. (Photo by John Bruna, Idaho Department of Lands.)

[1]Hall, Dale O. Uneven-aged stand decisions for optimum productivity. Manuscript in preparation.

STAND GROWTH ESTIMATES AND OPTIMIZING TECHNIQUES

Two important steps in identifying a "best" all-aged prescription are the estimation of growth for each trial prescription and the selection of an optimum. The growth of a prescribed stand is simulated and compared with the scale for optimum. The more accurate the growth projection, the better the odds for selecting a true optimum.

Growth projection techniques range from relatively simple stand table projections (Husch 1963), to more complex matrix solutions (Usher 1966), and to sophisticated computer models that use differential equations (Stage 1973; Adams and Ek 1974). The reliability for growth projection of one technique over another has not been demonstrated (Hann and Bare 1979).

Hann and Bare (1979) reviewed progress in optimizing techniques. They stressed Adams and Ek's (1974) nonlinear mathematical programing approach. Rorres (1978) and Buongiorno and Michie (1980) have used linear programing techniques. All these techniques require knowledge of sophisticated mathematical concepts and procedures, knowledge not usually available to field foresters. A second problem is that some solutions already exceed computer capabilities (Adams and Ek 1975).

Iterative optimizing techniques have been used with even-aged management (Larsen 1977) for many decades (Bentley and Teeguarden 1965). An iterative approach has recently been described for uneven or all-aged stand management (Chang 1981; Hall[2]). Hall uses a sophisticated and widely used growth simulator (Stage 1973) with some relatively simple computational procedures. There are two primary disadvantages: the method uses a "q" stand size distribution (Husch 1963[3]) that may be suboptimal; and a large number of projections are necessary to identify the "best" prescription.

The question of what measure to optimize is the owner's choice. Should it be based on biologic productivity—periodic annual increment in cubic volume or in merchantable volume? Or on some economic measure—internal rate of return, or land (soil) expectation value, or forest rent? All have their proponents. Most forest management texts discuss the relative values of each. The owner must clearly state a choice. This becomes the yardstick for the "test of best," the decision criterion.

Usually the "test of best" is constrained by some biologic, economic, sociologic, or managerial limits (table 1). Constraints, in our situation, must be expressed in terms of prescription elements or variables in the simulator. This may require some transformations and interpretations. For instance, deer or elk hiding cover is "vegetation capable of hiding 90 percent of a standing adult deer or elk from the view of a human at a distance equal to or less than 61 m (200 ft)" (Thomas and others 1979, p. 109). This may be interpreted as the relative number of small trees per acre with all-aged systems. Stand structure and density control the number of small trees (table 2). These relationships permit "deer and elk hiding cover" to be transformed to a constraint in terms of stand structure and density.

Evaluating prescriptions with different sets of constraints is one way of finding the relative values for potential trade-offs. After our initial discussion with a single set of constraints, we will look at some alternative constraints—trade-offs.

[2]Hall, Dale O. Financial maturity: for even-aged and all-aged stands. In press.

[3]Husch substitutes the symbol "r" for traditional "q".

Table 1.—Some effects of constraints on stand management options

Constraint	Effect
Tree size limits	Seed production potential Merchantable volume Tree value Equipment size (logging) Size of regeneration opening
Stand density	Seed germination Seedling survival Tree growth rate Relative proportion of merchantable volume Type and degree of site preparation possible
Interest rate	Land value (Max) tree size Merchantability limits Stand density Length of cutting cycle
Cutting cycle	Proportion of disturbed soil Amount and degree of compaction Proportion of stand harvested Area of annual cut Size of field crew Annual road maintenance Amount of slash developed

Table 2.—Number of small trees per acre (ha) as influenced by stand structure (q) and density (basal area)

DBH class		Basal area density 65 ft² (14.9 m²)				Basal area density 80 ft² (19.5 m²)	
Inches	*cm*	*q = 1.10*	*q = 1.20*	*q = 1.30*	*q = 1.50*	*q = 1.10*	*q = 1.20*
1.0–4.9	2.5–12.4	51 (126)	70 (173)	103 (255)	156 (385)	61 (151)	96 (237)
5.0–8.9	12.5–22.6	43 (106)	49 (121)	61 (151)	69 (170)	51 (126)	66 (163)

Setting a decision criterion and set of constraints will provide sideboards to the range of trial prescriptions to be tested (fig. 2). Experience in evaluating prescriptions will also tend to reduce the range of trial prescriptions. Two sets of prescription element values should be considered: one for initial trials and another for refining decisions (table 3). These sets are like a marksman's "zeroing round" and "match round."

Table 3.—Range in prescription values for initial and refining trials

Prescription element	Initial trials	Refining trials
Species composition	0.20–0.30	0.05–0.10
q	.20– .30	.05– .10
D.b.h., inches (cm)	3–4 (7–10)	1–2 (2–5)
Density, ft²/acre (m²/ha)	10–20 (2–4)	5 (1–1.5)

FOREST: ______ DECISION CRITERION: *Maximize Bare Land Value* PLANNER: *Hall and Bruna 2/10/81*

COMPT: *Boise Basin* HAB.TYP: *$^{PF}/_{CARU}$* NBR PROJ: i*j*k*l*m= *30*

STAND: ______ CONSTRAINTS: Discount rate 1.*05*; *STMPG appreciation rate = 1.03 Q ≥ 1.10; to insure reasonable quality selection options. Max. d.b.h. ≥ 16" to insure adequate seed for regen. Res. STKG ≤ 65 ft.^{2} b.a. to maintain light and moisture for repro. Cut CYC ≥ 12 yrs. to limit organization impacts. CF yield ≥ .90 CF potential to keep supplies high. CF harvest ≤ .50 CF VOL/AC to limit impacts on STD. BF harvest ≥ 2 m.b.f./AC to make logging profitable.*

LOCAT: ______

REMARKS: *BAI MULT = 2.15*

(1×2×3×3) + (1×2×2×3) = 30

PRESCRIPTION ELEMENTS:

(1) Spec Comp-(S_i)

Units = *FT^2 b.a.*

Sp	Code	Pct
A	*PP*	*100*
B		
C		
D		

-- M E A S U R E M E N T   U N I T S --

a) *PAI, CF* b) *PAI, BF* c) *CF, CUT %* d) *Bare land value $*

(2) Q_j q	(3) M_k Max dbh	(4) D_1 Res stk	(5) C_m CUTTING CYCLE *12*	*14*	*16*	(2) Q_j q	(3) M_k Max dbh	(4) D_1 Res stk	(5) C_m CUTTING CYCLE *12*	*14*	*16*	(2) Q_j q	(3) M_k Max dbh	(4) D_1 Res stk	(5) C_m CUTTING CYCLE *12*	*14*	*16*
1.10	*14*	*55*				*1.20*	*14*	*55*				*1.30*					
		60						*60*									
		65						*65*									
	16	*55*					*16*	*55*					*16*	*55*			
		60						*60*						*60*			
		65						*65*						*65*			
	18	*55*					*18*	*55*					*18*	*55*			
		60						*60*						*60*			
		65						*65*						*65*			

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Figure 2.—All-aged stand decision set selection and tabulation form for case study.

THE WINNOW PROCEDURES

Iterative procedures require examining a large number of alternative prescriptions to find the best one. The process is much like the winnowing of chaff from edible grain. Hence, the system of procedures and computer programs is named WINNOW (Hall[4]). The WINNOW iterative procedures are used to compare the estimated productivity of many all-aged stand prescriptions under a stated decision criterion and set of silvicultural-managerial constraints.

The automatic data processing (ADP) costs for the WINNOW procedure are generally controlled by the number of stand projections required. ADP costs will vary between installations. Our 1981 costs per projection were slightly less than $1.00 at Washington State University Computer Service Center. Costs for storage of WINNOW stand files is controlled by regularly deleting files as evaluations are completed.

We make a number of explicit assumptions in using WINNOW:

1. All-aged management has been selected.
2. Prescriptions are closely attainable in the field.
3. Reserve trees are selected with a conscious effort to maintain and improve growth and quality potentials.
4. After each harvest (at start of each growth period) a stand exactly matches its prescription.
5. Interharvest periods will not vary.
6. "q" values are for 2-inch (5-cm) d.b.h. classes.
7. Stand growth response to each trial prescription closely follows the simulator estimates.
8. Natural regeneration is adequate to maintain stand structures.
9. Economic variables change as predicted.
10. Costs of controlling stocking of submerchantable trees, after harvesting operations, are similar for all stand prescriptions and are nominal. (We made this assumption to simplify our explanation. The user could include such costs when needed, discount them, and include with other cost terms.)

Definitions and equations used in WINNOW are summarized in table 4.

We recognize that volume and value estimates are short-term estimates of limited reliability. We make a strong recommendation for applying the results of this, or any similar evaluation:

> *Continually monitor actual stand growth and value productivity for selected prescriptions. Reevaluate stand prescriptions as site specific productivity data become available.*

In our discussion we do not consider the transition path from a present stand to some desired future stand. Hann and Bare (1979) discuss integration of stands into a forest regulation model. WINNOW results could be entered into such a forest regulation model.

A CASE STUDY

Idaho State land managers, using WINNOW procedures, selected a "best" WINNOW (bW) prescription for some stands in their Southwest Area. This case study illustrates their use of the procedures and results of one bW evaluation.

The setting.—The Idaho Department of Lands has about 70,000 acres (28,330 ha) under all-aged management in their Southwest Area (Cooper 1976). Of special interest are some

Table 4.—Definitions and equations for use with WINNOW procedures

	Stand Descriptors	
s	= number of species in stand, $i = 1, s$.	
d	= number of size classes, $j = 1, d$.	
m	= smallest merchantable size class, $j = m, d$.	
t	= length of cutting cycle, years.	
$N(t)_{ij}$	= number of trees per unit area (/U) for species i and size class j.	
	Cubic Volume (CV) Units	
CV_{ij}	= CV of tree, species i, size class j.	
$CVT(t)$	$= \sum_{i=1}^{s} \sum_{j=1}^{d} CV_{ij}N(t)_{ij}$ = total stand CV/U, (stand table basis-aggregating).	[1.1]
$CVP(t)_{ij}$	= percent of stand CV/U, species i, size class j.	
CV_{ij}	$= [CVT(t) \times CVP(t)_{ij}]/N(t)_{ij}$ = CV of tree (stand volume basis-disaggregating).	[1.2]
$CVH(t)$	$= CVT(t) - CVT(0)$ = CV harvest.	[1.3]
$CVCUTP(t)$	$= CVH(t)/CVT(t)$ = CV percent cut.	[1.4]
$CVPAI(t)$	$= [CVT(t) - CVT(0)]/t$ = CV periodic annual increment,	[1.5a] or
	$= CVH(t)/t$.	[1.5b]
	Merchantable Volume (MV) Units	
MV_{ij}	= MV of tree (board feet, Scribner Rule), species i, size class j.	
$MVT(t)$	$= \sum_{i=1}^{s} \sum_{j=m}^{d} MV_{ij}N(t)_{ij}$ = total stand MV/U, (stand table basis-aggregating).	[2.1]
$MVP(t)_{ij}$	= percent of stand MV/U, species i, size class j.	
MV_{ij}	$= [MVT(t) \times MVP(t)_{ij}]/N(t)_{ij}$ = CV of tree (stand volume basis-disaggregating).	[2.2]
$MVH(t)$	$= MVT(t) - MVT(0)$ = MV harvest.	[2.3]
$MVCUTP(t)$	$= MVH(t)/MVT(t)$ = MV percent cut.	[2.4]
$MVPAI(t)$	$= [MVT(t) - MVT(0)]/t$ = MV periodic annual increment,	[2.5a] or
	$= MVH(t)/t$.	[2.5b]
	Economic Units	
S_{ij}	= present value per unit, volume or tree.	
p	= long term discount rate of organization.	
a	= real stumpage appreciation rate predicted.	
AC	= annual cost/U for administration and protection.	
$R(t)$	$= \sum_{i=1}^{s} \sum_{j=m}^{d} MV_{ij}N(t)_{ij}S_{ij}$ = revenue from merchantable volume.	[3.1]
C_b	$= \sum_{i=1}^{s} \sum_{j=m}^{d} MV_{ij}N(0)_{ij}S_{ij}$ = initial value of MV.	[3.2]
C_c	$= \sum_{i=1}^{s} \sum_{j=1}^{m-1} CV_{ij}N(0)_{ij}S_{ij}$ = initial value of sub-MV.	[3.3]
C	$= C_b + C_c$ = initial stand value (invested capital)	[3.4]

Land expectation value (LEV):

$$LEV = \frac{R(t)}{(1+p)^t - 1} - \frac{(1+p)^t - 1] + AC/p\,[(1+p)^t - 1]}{(1+p)^t - 1} \qquad [4.1a]$$

$$= \frac{R(t)}{(1+p)^t - 1} - [C + AC/p] \qquad [4.1b]^{1\ 2}$$

LEV with appreciating real stumpage value-

$$LEV = \frac{R(t)}{(1+p)^t/(1+a)^t - 1} - [C + AC/p] \qquad [4.2]$$

Annualized LEV or land rent equivalent (LRE):

$$LRE = LEV/p \qquad [5]$$

Discount/appreciation factor (simplifies computation of Eq. 4.2):

$$(1+p)^t/(1+a)^t - 1 = d/a \text{ factor.} \qquad [6]$$

[1]As 4.1b is formulated, the cost term (second term) is not influenced by cutting cycle length. Thus, the optimum prescription can be found from the maximum gross revenue term, i.e., without considering constant costs. The cost term must be included to find land expection value.

[2]If p is varied until LEV = 0 then p = the internal rate of return.

stands in the Boise Basin near New Centerville, Idaho (fig. 1).

The land type is mature with dissected mountain slopes in a dendritic drainage pattern. Soils are mainly gravelly-sandy-loam or sandy-clay-loam derived from well weathered granite.[5]

[4]See footnote 1.

[5]Unpublished report: Soil-hydrologic reconnaissance survey, 1973; Idaho City Ranger District, Boise National Forest, Idaho City, Idaho.

Slopes range from 20 to 50 percent with generally north to northwest aspects at 4,400 to 4,700 ft (1 340 to 1 430 m) elevation.

With 20 to 25 inches (51 to 64 cm) of rainfall per year, the dry Douglas-fir habitat types (h.t.) (Steele and others 1981) predominate—*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco/*Calamagrostis rubescens* Buckl. (PSME/CARU) (Douglas-fir/pinegrass) h.t. and *Pseudotsuga menziesii/Carex geyerii* Boott (PSME/CAGE) (Douglas-fir/elk sedge) h.t. sp. Fires have periodically burned through these dry forests providing a natural selection of the seral and fire-resistant species ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.).

Ponderosa pine is favored for management over Douglas-fir because it predominates in these stands. Ponderosa pine releases well and has good radial increment on these drier sites.

In this setting, foresters have asked: "What is the best all-aged silvicultural-managerial prescription for these ponderosa pine stands on a Douglas-fir/pinegrass habitat type?"

What is the owner's objective?—Let's first look at the foresters' decision criterion. The Idaho State constitution provides management direction for selecting the "best" prescription. This objective has been interpreted by the Department of Lands as:

> State Forest Lands shall be managed in a manner that will maintain and improve the timber productivity capacity to assure maximum long-term financial returns to the endowment funds. This management goal must be achieved without jeopardizing the other uses of state forested lands for watershed, forage, recreation, wildlife habitat and enjoyment of the aesthetic quality. (Operations Memorandum Number 901, August 1971, Department of Lands, State of Idaho [Cooper 1976]).

"Maximum long-term financial returns" is a clear, concise objective. We interpret the decision criterion to be maximum land expectation value (max LEV) (table 4, eq. 4.1a).

Further, it is generally accepted that real stumpage values are appreciating (Medema and Moore 1980; Hagenstein[6]). We recognize this by including an appreciation rate, a (table 4, eq. 6; table 5), in the LEV revenue term (table 4, eq. 4.2).

Then, because volume productivity measures are generally annual rates, let's convert LEV to an annual rate that will not change the relative standing of the trial prescriptions. We will call this the land rent equivalent (LRE) (table 4, eq. 5). Now:

Decision criterion = max LRE.

[6]Hagenstein, Perry. Alternative forest policies for the Pacific Northwest. Manuscript in preparation.

Table 5.—Revenue discount (p)/stumpage appreciation (a) factors (F) by cutting cycle (t) where: $F = \frac{(1+p)^t}{(1+a)^t} - 1$

Discount rate, p	Appreciation rate, a	Discount/appreciation factor, F for cutting cycle years 12	14	16
5	3	0.2596	0.3090	0.3603
6	3	.4113	.4947	.5831
8	3	.7662	.9418	1.1349
10	3	1.2012	1.5106	1.8635

What interest/discount rate should apply?—Economic theory suggests that an alternative rate of return (ROR), p, should be established for each organization. Investments not meeting the ROR should be liquidated and the resulting funds reinvested where the ROR will be produced. A recent analysis suggests that 5 percent is a reasonable ROR criterion for the State of Idaho Endowment Fund (Medema and Moore 1980). This represents a 3 percent real rate with a 2 percent risk premium. Then, for $(1 + p)^t$:

$p = 0.05 =$ ROR.

What tree or stumpage values are appropriate?—The values for merchantable volume, by tree size, were based on Department records. Values for smaller trees were derived as a compromise between planted costs, discounted future values, and estimated market values (table 6).

We constrain the decision criterion to meet other State income objectives, insure productivity levels, avoid "jeopardizing the other uses," and recognize State organizational limits and operational (logger) requirements.

What stumpage value appreciation rate should be used?—Medema and Moore (1980) summarized published estimates of increases in real stumpage prices. They found a range of between 3 and 3.5 percent. They used 3 percent in their analysis of management alternatives on Idaho State lands. We will also use a 3 percent annual rate. Then for $(1 + a)^t$:

$a = 0.03$.

Table 6.—Tree and stumpage values used for determining the best WINNOW (bW) prescription

Tree size class		Value
Inches	*cm*	*Dollars*
		per tree
1.0- 4.9	02-12	$ 0.25
5.0- 8.9	13-22	.90
		per MBF
9.0-12.9	23-32	$15.00
13.0-16.9	33-42	35.00
17.0-20.9	43-52	55.00
21.0+	53+	65.00

How much are the annual costs?—Area managers provided an estimate of annual costs, AC, to administer and protect these stands:

AC, dollars/acre(/ha) = \$2.60 (\$6.42).

The prescription constraints are based on the five elements of the prescription:

What species composition alternatives should be tried?—These stands were designated to produce only ponderosa pine because of growth and management considerations described earlier:

Species composition = PP@100 percent.

What stand structure (q) alternatives are reasonable?—As "q" decreases so does the relative number of stems in successively smaller size classes (table 2). With "q" = 1.10 there are 10 percent more trees in the next lower size class. This means that as all trees grow and pass to the next size class only one tree in 10 in each size class (except the largest) could die, be culled, or harvested and still maintain a "q" value of 1.10. Our professional judgment suggested this was a minimum "q" for the 2-inch (5-cm) size classes we use. Our trial set was:

q = 1.10, 1.20, 1.30.

What maximum d.b.h. alternatives do we have?—Our concern was for the maximum size trees (d.b.h.) to be left after harvest. Seed production is highly correlated with tree size. We needed to retain trees large enough to provide sufficient seed for natural regeneration of the stand. We estimated that dominant trees 16 inches (40.6 cm) in d.b.h. were the smallest trees to meet this criterion. Our trial set of maximum tree sizes was:

Max d.b.h., inches (cm) = 16, 18 (40.6, 45.7).

What stand densities are reasonable?—Regeneration and juvenile growth were again concerns in selecting the maximum reserve basal area standard. If stands were too dense, germination would be severely limited, seedling mortality high, and juvenile growth slow. Interharvest period also influenced density choices. Longer cycles would start with less dense stands to insure desired growth for the full period. We felt that 65 ft^2/acre (14.9 m^2/ha) of basal area was the maximum density to meet our criterion. Our trial set was:

Basal area density, ft^2/acre (m^2/ha) = 55, 60, 65 (12.6, 13.8, 14.9).

What interharvest periods are reasonable?—Presently, the Southwest Area uses a cutting cycle of 20 years. Staff members felt the organization could handle as short a period as 12 years. They also felt soils would not suffer from this frequent a reentry. Our trial set was:

Interharvest period, years = 12, 14, 16.

Area foresters recognized three special constraints—two on harvesting and one on productivity—as follows:

What limits apply to the volume cut?—Minimum merchantable volume harvest (MVH[t]) and maximum cubic volume harvest (CVH[t]) limits were identified. Some minimum volume must be removed for a logging operation to "break even" or become profitable. Experience suggested that a logger must harvest at least 2 M bd.ft./acre (5 M bd.ft./ha) to have a profitable operation.

On the other hand, removing too much volume would severely impact a stand and reduce growth. Again, experience suggested that no more than 50 percent of total cubic volume, CVT(t), should be removed at one harvest.

Our harvesting constraints were:

Min MVH(t), M bd.ft./acre(/ha) $\geq$ 2 (5)

Max CVH(t), percent $\leq$ 0.50 CVT[t]

Should a productivity limit be set? At what level?—When we started this study we had little knowledge of relationships between volume productivity and value productivity. We knew that support for Idaho schools came from the Endowment Fund but included some income taxes. Thus, maximum funds generated for schools would be some optimum mix of endowment funds and income taxes. We reasoned that maximum stand value yield might be significantly below cubic volume yield potential (max CVPAI), so that sawmill-generated income (and State income taxes) might be less under an optimum prescription. For this reason we set a minimum volume productivity limit based on the maximum productivity (max CVPAI) found in our trial set:

CVPAI(t) $\geq$ 0.90(max CVPAI).

It is appropriate to summarize the number of trial prescriptions (table 7), before considering measurement units.

Table 7.—Summary of trial prescription elements and number of trial projections

Prescription element	Trial levels	Number of trials
Species composition	PP @ 100 percent	1
Stand structure, q	1.10, 1.20, 1.30	3
Maximum tree size, d.b.h., inches (cm)	16, 18 (40.6, 45.7)	2
Stand density, basal area ft^2/acre (m^2/ha)	55, 60, 65 (12.6, 13.8, 14.9)	3
Interharvest period, year	12, 14, 16	[1] 1
Number of projections:		(1 × 3 × 2 × 3 × 1 = 18)

[1] One projection with printout at each trial year, that is, 12, 14, and 16.

What measurement units to use?—Measurement units for evaluating the bW prescription generally stem from the decision criterion, the constraints, and units used in growth projection. In our case we used periodic annual increment in cubic volume (CVPAI), merchantable volume (MVPAI), and land rent equivalent (LRE); from cubic volume measures we derived the cut percent—CVH(t)/CVT(t); we set a minimum merchantable volume harvest:

Our measurement units: CVPAI, MVPAI, LRE, CVH(t)/CVT(t), MVH(t).

The decision criterion, constraints, measurement units, and number of projections are summarized on the form shown in figure 2. The growth simulator, GPS, provides data for all but the LRE, which must be calculated by hand.

Data Processing

The data processing procedures have been kept simple. WINNOW and GPS are operational at the Computer Service Center at Washington State University. The center uses an IBM 370 with an AMDAHL V-8 operating system. Experienced programers should have little trouble in modifying WINNOW programs for other installations. We assume users are familiar with GPS (Wykoff and others 1982). The WINNOW programs and computation instructions are available through the senior author of this paper, Dale O. Hall.

Volume Productivity

Volume productivity data are readily summarized from GPS printouts (Wykoff and others 1982). The printout should include at least "Options and Input," "Stand Composition," and "Summary" ("Key Word" = "Summary") tables. "Options and Input" should be carefully checked for prescription accuracy. The "Stand Composition" table is used to find merchantable volume for each species and size class. The "Summary Table" provides net volumes in English units per acre[7] at specified times (t) (table 4, eq. 1.1 and 2.1). These tabulated volumes are used to calculate growth (PAI), harvest, and harvest percent (table 4, eq. 1.3, 1.5, 2.3, and 2.5).

These volume and/or other measures of attainment of objectives or constraints may be summarized for each trial stand and cutting cycle on the "Stand and Land Value Determination" form, shown in figure 3.

The merchantable volume must be distributed by species and size class to obtain reasonable value estimates for stand growth. The GPS "Stand Composition" table provides species and diameter distribution data by number of trees and cubic volume. We convert cubic volume species and size class proportions to similar proportions in merchantable volume.

The number of trees in the two smallest size classes is taken from the WINNOW stand tables (stand file).

Value Productivity

The calculation of value productivity has been greatly simplified. We assume that cycle length does not vary, revenues are the same at each future cut, and harvest returns the stand to initial condition and value. We use present values in calculating initial stand investment value and the future revenue for each cutting cycle—the discount/appreciation (d/a) factor will account for trends in future values (table 4, eq. 6 and 4.2; table 5).

Stand investment value is the sum of all size class values per unit area for all species, at time t, $t = 0$ (fig. 3, col. 7). Stand revenue at t is the sum of **merchantable** size class values per unit area for all species using the **present** values per thousand board feet.

In the Idaho case study we had only one d/a combination. We calculated the d/a factor for the three trial interharvest periods and made a simple table (table 5, line 1).

The end-of-period revenue divided by the appropriate d/a factor gives the present value of an infinite series of like revenues.

Total cost in this formulation (table 4, eq. 4.1b) is the sum of initial stand investment value, C, and equal annual costs accumulated and discounted to the present, AC/p.

LEV (table 4, eq. 4.1) is the algebraic sum of total cost and gross value of accumulated revenues. LEV is the estimated value of the specified land (bare) for growing an infinite series of like tree crops under the assumptions of the prescription, the growth model, and the economic evaluation model.

Comparing LEV's, or their transforms, LRE's (table 4, eq. 5), will show the relative economic productivity of different prescriptions for the same site, of different sites, and of different forms of management: even-aged (Larsen 1977) and all-aged (Hall[8]).

Winnowing Prescriptions

In our case study, we projected the 18 trial prescriptions (table 7) with GPS specifying summary prints at 12, 14, and 16 years (the three cutting cycles), made the 54 economic evaluations, and tabulated the results (table 8).

Our constraints served two purposes: to limit the number of trial prescriptions, and to limit the number of "acceptable" projections. An acceptable projection has met all constraints and will be tested against the objective or decision criterion.

Winnowing the volume productivity results through our constraints we find that:

max CVPAI = 117 ft^3/acre/yr (8.19 m^3/ha/yr)
Prescription: PP100–1.20–16–65–12;
(PP100–1.20–40.6–14.9–12)

hence:

min CVPAI(t) $\geq$ 0.90 $\times$ 117 = 105 ft^3/acre/yr or
min CVPAI(t) $\geq$ 0.90 $\times$ 8.19 = 7.37 m^3/ha/yr (use 7.35 m^3/ha/yr).

Prescriptions producing less than the minimum acceptable CVPAI are "chaff" (shaded values in table 8).

Continuing the winnowing process we find that our harvest limit,

max CVH(t) $\leq$ 0.50 CVT (t),

eliminates all but one prescription with a 16-year cutting cycle and all but four with 14-year cycles. All prescriptions with 12-year cycles meet the constraint. Prescriptions not meeting harvest limits are shown with hatched lines (table 8).[9]

[7]Conversion factors we used for metric units are:
m^3/ha = 0.0700 ft^3/acre
m^3, merchantable = 424 bd.ft.
m^2/ha = 0.2296 ft^2/acre

[8]See footnote 1.

[9]Had efficiency in using the procedure been one of our study objectives, we could have foregone economic evaluation for 40 of the 54 trial prescriptions based on their failure to meet two volume constraints—(CVPAI[t]) $\geq$ (0.90 Max CVPAI), and CVH(t) $\leq$ (0.50 CVT[t])—the shaded and hatched portions of table 8. We made the 54 economic evaluations to see more clearly the value relationships between prescription elements and to allow comparisons when different objectives and constraint sets were used.

Form .—Stand and Land Value Determination. Unit IDL-DF/CARU ; Planner Hall and Bruna: 4/4/81 Q311065

(2) Inter-harvest period (yr), t = 0 (1) Stand ID

(8)

	t = 12	t = 14	t = 16
PAI-CF =	114 M^3/ACRE	112	110
PAI-BF =	473 b.f./ACRE	473	470
CF Cut Pct =	.46	.49	.52

SPECIES PONDEROSA PINE - 100%

(3) Tree Value-Size Classes (in)	(cm)	(4) Part of Total Volume (pct)	(5) Quantity Per Unit Area (nbr/mbf)	(6) Value/ Unit Quantity (dollars)	(7) Value Per Unit Area (dollars)	t = 12 Part of Total Volume (pct)	Quantity Per Acre (mbf)	Value Per Acre ($)	t = 14 Part of Total Volume (pct)	Quantity Per Acre (mbf)	Value Per Acre ($)	t = 16 Part of Total Volume (pct)	Quantity Per Acre (mbf)	Value Per Acre ($)
1.0- 4.9	02-12		51.4	$0.25	$12.85									
5.0- 8.9	13-22		42.5	0.90	38.25									
9.0-12.9	23-32	.66	2.981	15.00	44.72	.18	0.997	14.96	.15	1.018	15.27	.11	0.827	12.41
13.0-16.9	33-42	.34	1.565	35.00	54.78	.33	1.870	65.43	.33	2.181	76.33	.39	2.932	102.62
17.0-20.9	43-52	—	—	55.00	—	.48	2.742	150.81	.43	2.835	155.93	.44	3.308	181.94
21.0+	53+	—	—	65.00	—	.01	0.062	4.05	.09	0.581	37.80	.06	0.451	29.32

SPECIES NONE

(in)	(cm)	(4)	(5)	(6)	(7)									
1.0- 4.9	02-12													
5.0- 8.9	13-22													
9.0-12.9	23-32													
13.0-16.9	33-42													
17.0-20.9	43-52													
21.0+	53+													
		1.00 ✓	4.546	Stand Invest't	$150.59	1.00 ✓	5.671	235.25 Revenue	1.00 ✓	6.615	285.32 Revenue	1.00 ✓	7.518	326.29 Revenue

(9) Int Rate, i	(10) Appr Rate, a	(11) Accum Ann Cost	(12) Total Cost	(13) Dsct/ Appr/ Factor	(14) Gross Value Reven's	(15) Land Exp'tn Value	(16) Annual Rent Equiv't	Dsct/ Appr Factor	Gross Value Reven's	Land Exp'tn Value	Annual Rent Equiv't	Dsct/ Appr Factor	Gross Value Reven's	Land Exp'tn Value	Annual Rent Equiv't
1.05	1.03	52.00	202.59	.2596	906.21	703.62	35.20	.3090	923.37	720.78	36.05	.3603	906.61	703.02	35.15
1.08	1.03	32.50	183.09	.7662	307.07	123.98	9.92	.9418	302.95	119.86	9.59	1.1349	287.81	104.48	8.35

INT-1208-D011 Ver 1.1 (4/81) NOTE: COLUMN TOTALS MAY NOT SUM EXACTLY DUE TO ROUNDING.

Figure 3.—Stand and land value determination form for bW prescription.

Table 8.—Comparative simulated yields from alternative all-aged prescriptions for a Douglas-fir/pinegrass-ponderosa pine habitat type in central Idaho

Prescription Elements, 1-5 (1) Species composition: PP@100 percent			Periodic Annual Increement: Land rent equivalent			Merchantable volume			Cubic volume			Portion periodic cubic volume harvested		
(2)	(3) Max	(4) Res	(5) CUTTING CYCLE, YEARS											
"q"	d.b.h.	stkg.	12	14	16	12	14	16	12	14	16	12	14	16
			Per acre per year											
	Inches	*Ft²*	*Dollars*			*Board feet*			*Cubic feet*			*Percent*		
1.10	16	55	32.35	32.85	33.30	430	431	431	103	102	101	48	51	54
		60	34.05	34.85	34.50	453	454	452	109	107	106	47	50	53
		65	35.20	36.05	35.15	473	473	470	114	112	110	46	49	52
	18	55	29.90	30.75	30.70	377	377	381	94	93	92	43	47	50
		60	32.15	32.30	32.30	399	398	401	100	99	97	42	46	49
		65	33.10	32.60	32.05	416	414	417	105	103	101	42	45	48
1.20	16	59	30.35	31.75	30.75	423	425	425	106	105	104	49	53	56
		60	32.30	33.00	32.25	449	450	449	112	111	109	49	52	55
		65	31.90	32.45	31.55	468	468	467	117	115	114	48	51	54
	18	55	27.95	28.45	28.70	384	383	387	99	98	97	45	49	52
		60	29.15	29.80	29.90	405	404	406	104	103	101	45	48	51
		65	31.55	30.30	30.45	441	420	422	109	107	105	44	47	50
1.30	16	55	23.45	24.40		377	383	390	101	101	102	49	53	56
		60	24.30	25.20		397	402	408	106	105	105	48	52	55
		65	25.10	25.65		417	418	423	110	109	109	47	50	54
	18	55	23.20	23.20		348	347	359	96	95	95	45	49	52
		60	23.85	23.95		364	362	373	100	99	99	44	45	51
		65	24.15	25.05		378	380	384	104	103	102	43	47	50
			Per hectare per year											
	cm	*m²*	*Dollars*			*Board feet*			*Cubic meters*			*Percent*		
1.10	40.6	12.6	79.95	81.15	82.30	1063	1065	1065	7.21	7.14	7.07	48	51	54
		13.8	84.15	86.10	85.25	1119	1122	1117	7.63	7.49	7.42	47	50	53
		14.9	87.00	89.10	86.85	1169	1169	1161	7.98	7.84	7.70	46	49	52
	45.7	12.6	73.90	76.00	75.85	932	932	941	6.58	6.51	6.44	43	47	50
		13.8	79.45	79.80	79.80	986	983	991	7.00	6.93	6.79	42	46	49
		14.9	81.80	80.55	79.20	1028	1023	1030	7.35	7.21	7.07	42	45	48
1.20	40.6	12.6	75.00	78.45	76.00	1045	1050	1050	7.42	7.35	7.28	49	53	56
		13.8	79.80	81.55	79.70	1109	1112	1109	7.84	7.77	7.63	49	52	55
		14.9	78.80	80.15	77.95	1156	1156	1154	8.19	8.05	7.98	48	51	54
	45.7	12.6	69.05	70.30	70.90	949	946	956	6.93	6.86	6.79	45	49	52
		13.8	72.05	73.65	73.90	1001	998	1003	7.28	7.21	7.07	45	48	51
		14.9	77.95	74.85	75.25	1090	1038	1043	7.63	7.49	7.35	44	47	50
1.30	40.6	12.6	57.95	60.30		932	946	964	7.07	7.07	7.14	49	53	56
		13.8	60.05	62.25		981	993	1008	7.42	7.35	7.35	48	52	55
		14.9	62.00	63.40		1030	1033	1045	7.70	7.63	7.63	47	50	54
	45.7	12.6	57.35	57.35		860	857	887	6.72	6.65	6.65	45	49	52
		13.8	58.95	59.20		899	894	922	7.00	6.93	6.93	44	48	51
		14.9	59.65	61.90		934	939	949	7.28	7.21	7.14	43	47	50

Note: Shaded values do not meet productivity constraint = 0.90 × (cubic volume yield potential). Hatched values fail the harvest constraint = 0.50 × (stand cubic volume).

Our board-foot harvest constraint,

MVH(t) $\geq$ 2 m.b.f./acre (5 m.b.f./ha),

was not operational; that is, all board-foot harvests were at least twice the established limit.

The last comparison was against the decision criterion, the "test of best":

max LRE = bW prescription.

The tentative bW prescription was:

PP100–1.10–16–65–14 (table 9)
(PP100–1.10–40.6–14.9–14).

Table 9.—Size distribution and characteristics of the best WINNOW prescription for Douglas-fir/pinegrass-ponderosa pine habitat type, central Idaho

DBH		Stems per acre	Stems per hectare
Inches	*cm*		
4	10.2	22.0	54.36
6	15.2	20.0	49.42
8	20.3	18.2	44.97
10	25.4	16.4	40.52
12	30.5	15.0	37.07
14	35.6	13.7	33.85
16	40.6	12.4	30.64
Total		118	290.83

Mean D = 10.1 (25.7)
Stand density index: trees/acre(/ha) = 120 (300)

Note: The prescription is
species composition = 100 percent ponderosa pine
stand structure, "q" = 1.10
reserve stocking, basal area = 65 ft²/acre (14.9 m²/ha)
maximum reserve tree size, d.b.h. = 16 inches (40.6 cm)
cutting cycle = 14 years.

Proving the Best

On selection of one of the trial prescriptions, the question of refining the prescription comes up. In our example the only prescription element that could change our choice of bW, within our constraint framework, is the cutting cycle; 13- or 15-year cycles might produce a greater LRE. Because of the indicated relationships we felt that the 14-year cycle was best.

Our selection was still tentative. We asked ourselves:

1. Does the GPS projection seem realistic in view of our knowledge base?
2. Are our economic evaluations reasonable expectations?
3. Will these prescription elements fully meet our constraints?
4. Have we included **all** the necessary constraints for these stands...biologic, economic, sociologic?

In effect, we now knew what the prescription and stand looked like (table 9). We reversed our perspective and asked, did it fully meet the objective and constraints, and was it realistic? We also sought independent opinions from other foresters. When we found no serious criticism, we finally accepted it as our bW prescription.

Applying the bW Prescription

Implementation of the bW prescription requires carefully considering other questions before application:

1. What steps should be taken to move the stand from its present condition to the desired prescription? What time frame?
2. What are the site limits for applying the prescription?
3. How are individual trees selected to avoid undesirable alterations to the gene pool?
4. Are all **age** classes present or have smaller trees just been less vigorous?
5. What relative size/spacing standard should be used?

COSTS AND RETURNS FOR bW ALTERNATIVE USE PRESCRIPTIONS

The estimated relationships between different prescriptions and stand potentials are enlightening. Some managers advocate producing the maximum cubic volume (max CVPAI). They may make such advocacy without appreciating the cost of their actions (table 10, a and b). The objective of maximum cubic volume production shows an annual cost (reduction in LRE) of \$4.96/acre (\$10.30/ha) for a gain of 5 ft³/acre (35 m³/ha) in volume over the prescription which maximizes LRE. Obtaining the last 4 percent in potential volume carries a high cost—14 percent of stand value every year.

Resource values other than timber may be compared in this framework. Consider an alternative constraint to increase water yield; stand density to be 55 ft²/acre (12.6 m²/ha) in basal area. This 15 percent reduction in stand density (basal area) over a watershed should increase water yields by 0.5 inch (1.3 cm). The irrigation value of water in central Idaho in 1980 was about \$25/acre foot (\$2.024/100 m³) (personal communication, Joe Rabb, Boise, Idaho, November 1980). Assuming no significant loss in volume during transport, the extra water yield (value of \$1.04/acre or \$2.57/ha) had a net **cost** to the watershed each year of \$4.66/acre (\$11.85/ha) (table 10, a and c).

Wildlife resource values, as described earlier, may also be compared. Assume that about 100 trees, 1 to 4 inches d.b.h./acre (250 trees, 2 to 12 cm d.b.h./ha) will provide the required deer and elk hiding cover (Thomas and others 1979) in a stand. A "q" value of 1.30 with 65 ft²/acre (14.9 m²/ha) basal area will provide this many small trees (table 2) so we set our big game hiding cover constraint as: q $\geq$ 1.30. We then compare with the best timber prescription (table 10, a and d). The prescription insuring deer and elk hiding cover will yield \$10.40/acre (\$25.70/ha) less each year than would the best timber prescription.

SUMMARY AND CONCLUSIONS

We have examined the problem of selecting the best silvicultural/managerial prescription for an all-aged stand. The two phases of the problem are projecting growth and selecting the optimum prescription. Although any growth projection method could be used, we interface with Stage's (1973) growth prognosis system (GPS). We use Hall's[10] iterative WINNOW procedures to select the best prescription for a stand on State of Idaho lands.

Stands are described by five parameters: species composition, stand structure ("q"), maximum reserve tree size (d.b.h.), stand density (basal area), and interharvest period. We vary these parameters and examine 54 alternative prescriptions. The WINNOW programs efficiently and quickly map many stand prescriptions to tree records and stand files and then interface stand files with GPS to estimate volume growth and yields. A simple calculation procedure provides estimates of economic productivity in terms of land expectation value (LEV) and annual land rent equivalent (LRE).

[10]See footnote 1.

The numerous estimated volume and value yields are "winnowed" through prespecified silvicultural and managerial constraints. The remaining prescriptions are compared against the owner's "test of best" to pick one best WINNOW (bW) prescription. Finally, the selected prescription is examined carefully, in the light of all available experience with the stand, testing for silvicultural and managerial realism and consistency. When accepted, the bW prescription becomes the goal toward which the stand should be moved. Potential yields and values constrained for different resource needs may be readily compared with maximum timber productivity.

The methods and procedures described are relatively simple to use. Once growth projections are in hand, the sophisticated economic evaluations take a few simple desk calculations.

Application of bW prescriptions should generally increase volume and/or value yields. In our case study stand in Idaho, we compared the bW prescription against a 12-year no-treatment projection (table 10, a and e). The bW prescription showed an estimated 30 percent increase in cubic volume yield, a 100 percent increase in merchantable volume yield, and a 400 percent increase in value productivity. The stand manager scheduled early treatment to move the stand toward the bW prescription.

Table 10.—Relative productivity estimates for best WINNOW prescriptions to meet five different management objectives and constraint sets for Douglas-fir/pinegrass-ponderosa pine habitat type, central Idaho

Prescription elements	Management objective: a) Maximum LRE, timber	b) Maximum cubic vol., PAI, timber	c) Maximum LRE, timber and water[1]	d) Maximum LRE, timber and hiding cover	e) No treatment
			Best WINNOW prescription		
Species composition, percent b.a.	1.00	1.00	1.00	1.00	1.00
Stand structure, "q"	1.10	1.20	1.10	1.30	1.70
Maximum tree size, d.b.h., inches (cm)	16 (40.6)	16 (40.6)	16 (40.6)	16 (40.6)	26 (66.0)
Reserve stocking, b.a., ft²/acre (m²/ha)	65 (14.9)	65 (14.9)	55 (12.6)	65 (14.9)	136 (31.1)
Cutting cycle, year	14	12	12	14	12
			Estimated annual growth for prescription[2]		
Value (annual rent), \$/acre (\$/ha)	36.05 (89.10)	31.55 (78.80)	31.39 (77.57)	25.65 (63.40)	7.90 (19.52)
Merchantable volume, b.f./acre (b.f./ha)	473 (1169)	441 (1156)	423 (1045)	418 (1033)	230 (568)
Cubic volume, ft³/acre (m³/ha)	112 (7.84)	117 (8.19)	106 (7.42)	109 (7.63)	85 (5.95)
Basal area, ft²/acre (m²/ha)	2.3 (0.53)	2.6 (0.60)	2.3 (0.53)	2.6 (0.60)	2.4 (0.55)
Quadratic mean diameter, inches (cm)	0.176 (0.447)	0.208 (0.528)	0.217 (0.550)	0.200 (0.508)	0.050 (0.127)
Rings per inch (cm)	11.4 (4.5)	9.6 (3.8)	9.2 (3.6)	10.0 (3.9)	40 (15.7)

[1]Water valued at \$25/acre foot (\$2.024/100m³) with a 0.5 inch/acre (1.3cm/ha) increase in water yield.
[2]All but value growth estimates from Stage's (1973) growth prognosis model adjusted with growth plot data provided by Southwest Area, Department of Lands, Boise, Idaho.

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The relatively simple set of WINNOW procedures and computer programs for simulating and selecting one best silvicultural/managerial all-aged prescription from many alternatives is described. The selection basis may be sustained annual volume or value productivity measures. An economic case study evaluates constrained prescription alternatives for a stand of ponderosa pine on a Douglas-fir/pinegrass habitat type in central Idaho. Maximum land (soil) expectation value, based on a new formula for all-aged stands, is the decision criterion. The selected prescription shows potential increases in cubic volume productivity of 30 percent, in merchantable productivity 100 percent, and in value productivity 400 percent. Trade-offs for prescriptions with increased water yield or increased big game hiding cover are compared.

KEYWORDS: soil expection value, uneven-aged stand management, stand prescriptions

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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